The Social Determinants of Cancer
A Challenge for Transdisciplinary Science

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Abstract: To make further significant advances in cancer control research, a transdisciplinary science approach is needed that integrates the study of the biological nature of cancer and its clinical applications with the behavioral and social influences on cancer. More-effective interventions to reduce the burden of cancer can be developed and implemented by the adoption of a transdisciplinary research framework that takes into account the social determinants of cancer and seeks to discover interactions among social, environmental, behavioral, and biological factors in cancer etiology. This paper addresses two critical issues in the science of team science: (1) a cross-disciplinary, multilevel framework for organizing future research, and (2) a perspective that could aid in the translation and dissemination of cancer research findings in health care and public health practice. This conceptual framework is designed to encourage transdisciplinary research that will integrate social determinants into cancer research. The authors' goal is to promote a more complete understanding of the causes of cancer that will lead to the improved translation and implementation of the results of research.
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Introduction

Cancer is a group of diseases that impose a heavy burden on the public health and pose a challenge to science. While the century-long trend of increasing cancer mortality in this country was reversed in the mid-1990s, cancer remains the second leading cause of death,[1] the toll on human suffering is profound, and its economic costs to society are substantial.[2] Furthermore, cancer presents an intellectually complex set of problems because of multiple sites and causation, inadequately understood biology, and myriad intervention strategies. Impressive progress has been made against cancer, but not solely because of new knowledge about its genetics and molecular biology or new therapeutic approaches. Progress has also followed in the footsteps of understanding the social and behavioral determinants of cancer.

To make further significant advances in cancer control research, a transdisciplinary approach is needed that integrates the study of the biological nature of cancer and its clinical applications with the behavioral and social influences on the disease. Cancer research is an example of how the complexities of modern science require teams of investigators from many disciplines.[3] Transdisciplinarity is a process in team science in which members share conceptual and methodologic frameworks to integrate concepts from their own disciplines with those of other scientists to solve a particular problem at hand; in doing so, they develop new concepts and perspectives that go beyond their own disciplines.[4–8] It differs from a multidisciplinary approach in which groups of scientists independently or sequentially apply their own disciplinary perspectives to a problem, and from an interdisciplinary approach in which scientists are integrated as a team but still work independently from their own disciplinary perspectives. The unexpected and novel insights generated by transdisciplinary science come from a truly integrated team approach in which scientists are willing to hold their own knowledge lightly and to seek new perspectives from interaction with others. Examples of successful transdisciplinary science can be found in the fields of bioengineering, environmental economics, space science, meteorology, and others.[9–11] It can be argued that taking a cells-to-society approach in cancer control science means that more-effective interventions can be developed and implemented to reduce the burden of cancer. To accomplish this, the perspective advanced by the IOM and others that uses a socioecologic model is supported by the authors.[3,12]

The socioecologic model or perspective implies reciprocal causation between the individual and the environment that essentially defines interactive ef-

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fects.[13] First developed to explain human behavior within society,[14] this model has been increasingly applied to broaden the understanding of health issues.[15] However, to fully operationalize the socioecologic model and concepts like the web of causation[16] and embodiment,[12] a range of scientific perspectives is required. Transdisciplinary cancer control research provides a framework for bringing the interdisciplinary range of scientists together so that they can study and analyze the wide range and types of inputs located at various levels (from cells to society). The goal of transdisciplinary science is to yield a detailed and vivid snapshot of the impact of the web of causation and to rationalize interventions at various critical points in the resulting picture.

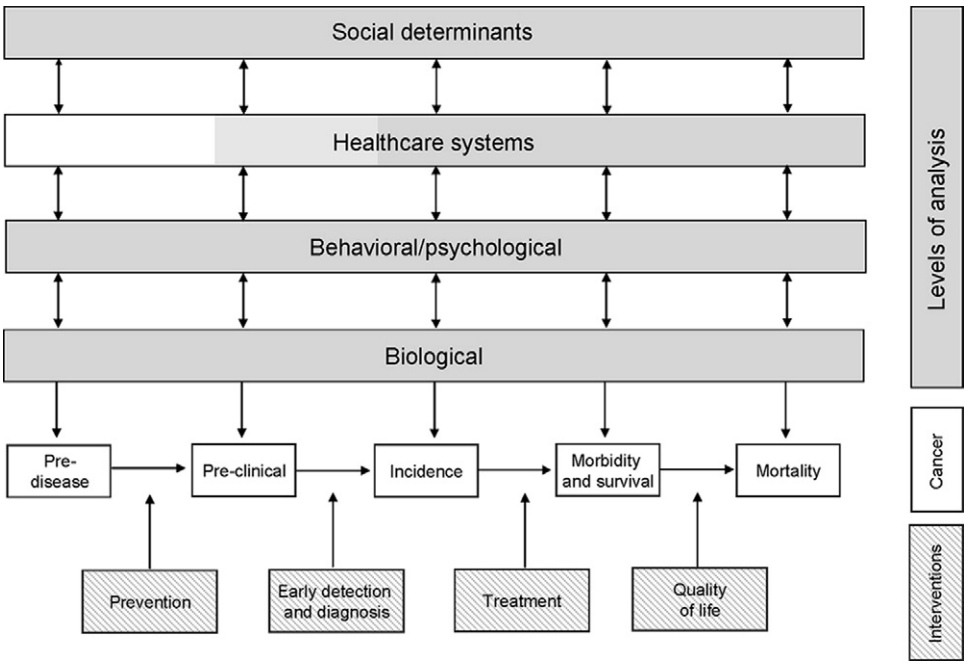

Figure 1. Social determinants of cancer. Framework illustrates how social determinants relate to other levels of analysis and types of interventions along the cancer continuum. Healthcare systems are less likely to influence cancer incidence than mortality and are lightly shaded in the preclinical phase of the continuum.

The authors' definition of social determinants encompasses social and economic conditions such as poverty, the conditions of work and healthcare delivery; the chemical toxicants and pollutants associated with industrial development; and the positive aspects of human settlements that make active living and healthy eating possible. The socioecologic model incorporates and augments discoveries in cancer biology and clinical oncology, in addition to those from the social sciences. A key question in cancer research is why social determinants are important: Is it because of their indirect effects through individual risk factors or behaviors, like smoking; because they interact with genetic and other biological factors (e.g., gene–environment interactions); because they are direct and irreducible causes of illness regardless of intervening variables[3,17]; or because of all these reasons? Krieger[18] has recently proposed the banishment of the terms *proximal* and *distal* to emphasize the importance of avoiding linear causal thinking and to consider how social determinants might act across non-adjacent levels.

Two critical issues in the science of team science are addressed in this paper[7]: (1) a cross-disciplinary, multilevel framework for organizing future research, and (2) a perspective that could aid in the translation and dissemination of cancer research findings in health care and public health practice.[3,4] This conceptual framework (Figure 1) is designed to encourage transdisciplinary research that will integrate social determinants into cancer research. The goal is to promote a more complete understanding of the causes of cancer, leading to the improved translation and implementation of research results.

Framework

This framework is designed to aid in conceptualizing how social determinants interact with other factors in the etiology of cancer and to capture changes over time. It begins with the cancer continuum,[19] adds levels of analysis,[20–22] and considers the impact of interventions along the continuum.[23,24] It draws on the grid elaborated by Krieger[25] to distinguish domains of social inequality across the cancer continuum. Throughout, the need is stressed for a transdisciplinary approach to bring these concepts together. This framework invites researchers from all disciplines to engage in cancer research within the context of its social determinants as part of the "bold experiment" of transdisciplinary research.[26]

The Cancer Continuum

The cancer continuum forms the horizontal axis for the framework and illustrates the course of cancer from disease-free through preclinical early cancer to diagnosis, to survivorship, and to end-of-life and death.[19] Each phase is influenced by different factors in the social environment, and together they incorporate a life-course approach. Different disciplines usually focus on

different stages of this continuum, but the authors contend that a transdisciplinary approach that considers and integrates research questions and findings all along this continuum and over the life course could yield more valuable scientific outcomes.

Multiple Levels of Analysis

The concept of *levels of analysis* used by Anderson[27] forms the basis for elucidating social factors that influence cancer incidence and mortality. A healthcare level[28] influenced by social forces and critical to cancer outcomes has been added. Multiple additional levels could be introduced into this framework (as has been done in other models[29]) as they are needed to highlight specific research approaches or pathways (e.g., the physical environment). For simplicity, four levels have been selected. First, the focus is on broad social conditions and policies; second, on the impact of healthcare systems; third, on behavioral and psychological factors; and finally, on the biological mechanisms of carcinogenesis. Interventions to reduce disparities and the burden of disease may be introduced at any of these levels.

Although this framework represents these relationships as a simple, linear process, they are neither simple nor linear.[30] Complex, multidirectional interactions link biological, clinical, and broader social influences into a web of causation.[16,18] For example, biological factors can influence behavior and generate a need for healthcare interventions. Also, policies and legislation concerning coverage for health care can shape individual behaviors and the use of clinical services. This complex, multidirectional interaction of social determinants with other levels challenges researchers working in all areas of cancer investigation to consider the specific pathways and mechanisms that might link their results to fundamental causes. Because cancer involves the complete spectrum of scientific endeavor from genes to society, a transdisciplinary research perspective may be the best approach for understanding the complex, multilevel causal mechanisms and pathways needed to inform cancer control interventions and policies.

Social Determinants

Social determinants have been called the fundamental causes of health and disease,[31] and this is how the term is used here. They are also characterized as the *upstream* or *distal* social, environmental, economic, and cultural factors that shape or determine individual and group behavior.[32–34] In the framework, social determinants include the physical and built environment that are part of or the result of human activity. Krieger[25] enumerated the key social determinants of cancer in her grid. Others also have discussed how fundamental causes and upstream events influence population health.[33,35–37] Although associations between social determinants and population health outcomes may sometimes appear self-evident, few causal relations have been rigorously established.

Understanding how resources and forms of discrimination are distributed in the population is key to understanding fundamental causes. Common measures of socioeconomic resource distribution include occupation, income, wealth, poverty, debt, employment status, education, and health-insurance coverage. Discrimination occurs on the basis of race, gender, age, sexual orientation, and other factors. These distributions can be measured at various levels (e.g., individual, community, county, state, national). Clearly these fundamental causes affect a broad range of health outcomes (e.g., cardiovascular diseases, diabetes, cancer), and a strong case has been made for shifting from the traditional NIH disease-specific approach to an approach that considers the multiple outcomes of common causes.[3] Yet much can be learned by focusing on a particular disease as long as researchers recognize that the social determinants of that disease may have other downstream health consequences.

Examining the distributions of social determinants at various levels across the cancer continuum exposes nonrandom patterns of cancer-related behaviors and outcomes among groups or individuals that may inform key biological mechanisms or be influenced by them.[38] The transdisciplinary research task is complex, and will require teams of scientists willing both to teach aspects of their disciplines to scientists in other fields and to engage in the painstaking task of formulating new conceptual models more appropriate to the problem. However, such a transdisciplinary approach may be just what is needed to realize cancer control objectives, such as those in *Healthy People 2010*.[39,40]

The Role of the Healthcare System in Cancer Incidence and Mortality

The relative importance of health care versus social-level factors has been hotly debated in the population health literature.[33,41,42] A challenge for cancer control research is to clearly distinguish outcomes that are due to deficiencies in healthcare delivery from those external to it, so that interventions can be appropriately targeted. Although it might not be the case in an ideal health system in which due attention is paid to prevention as well as clinical services, in current-day practice the evolution of cancer is less likely to be influenced by health care prior to screening and clinical diagnosis than it is later in the cancer continuum. Cancer has a preclinical phase that begins when cancer can be prevented and extends through its initiation until detection. During the preclinical phase, access to health care can affect the progression of cancers for which early-detection procedures are available (i.e.,

breast, cervix, colon, prostate), but overall this access is less likely to influence cancer incidence (and is thus lightly shaded for emphasis in the framework).[17] To understand social gradients and racial and ethnic inequalities in incidence, the broader social determinants of cancer—beyond the usual scope of medical care—must be explored.

Cancers, Not Cancer

A critical point is that cancer is actually many different diseases with different etiologies. The social environment may affect these different types of cancer in different ways. Cancer registries currently report approximately 80 types of malignant neoplasm, and define them by their location and cell types.[43] However, four sites account for approximately one half of all cancer incidence: Breast (15%); prostate (17%); lung (13%); and colon (8%) cancers accounted for 52% of all estimated new cancer diagnoses in 2006.[44] The concentration of cancer incidence among these four sites provides an opportunity for site-specific inquiry into the social determinants of cancer. For example, lung cancer mortality is strongly associated with tobacco use and social policies. Breast and colon cancer mortality is shaped by the distribution of screening in the population. Even though breast cancer incidence is more common in higher-SES women, mortality is higher among lower-SES women.[45,46] There are also important differences in incidence by race and ethnicity in different cancer sites. While Vietnamese and Hispanic women have some of the lowest rates of breast cancer incidence, they have the highest rates of cervical cancer incidence.[47] Thus, cancer offers some paradoxes and evokes research questions that may shed light on the various ways that social determinants affect cancer outcomes.

Measuring Disparities in Cancer Incidence and Outcomes

Cancer Registries

Cancer is unique among the chronic diseases in having long-standing population-based registries. Since the early 1970s, cancer registries have abstracted medical records, pathology, surgery, hospital, and outpatient clinic records on cancer incidence, survival, and mortality.[43] Registry data have been the main source of questions raised about cancer–health disparities. However, registries have lacked the data necessary to fully answer these questions on the SES of cancer cases. The first linkage between surveillance, epidemiology, and end result (SEER) registry data and areal SES data was published in 1980.[48] Currently, SEER registry cases are routinely geocoded and linked to county-level census data on SES (seer.cancer.gov/seerstat/variables/countyattribs/). Areal socioeconomic data can supply a proxy for individual SES or provide information about the context in which an individual resides, such as neighborhood or county characteristics.[22,49,50] Advances in information technology, linkage methods, and improved data systems can deliver tools to improve the value of cancer registration to understanding social determinants within the context of a transdisciplinary approach to cancer research[51]; however, political action will be needed to actualize that potential.

Socioeconomic Gradients in Cancer

Socioeconomic gradients in health and mortality are well-documented, although this relationship for cancer does not appear to be as strong as for cardiovascular disease.[52–55] Analyses of linked cancer registry and county-level census data have been used to document gradients and disparities for mortality, survival, and incidence.[45] Linked databases have also allowed researchers to examine the effect of SES factors on individuals in the contexts in which they live and work,[56,57] by cancer stage,[22] and for other diseases.[58]

At the population level, if socioeconomic gradients in cancer incidence and outcomes persist after adjusting for known risk factors (e.g., tobacco use and other risky behaviors) and for screening, that finding would provide empirical support for the value of seeking direct biological pathways between the adverse conditions associated with lower SES and cancer. A recent study compared health outcomes for which prevention and therapeutic interventions are available to outcomes for which they are not, and found stronger SES gradients for outcomes with proven interventions.[17] The authors concluded that the underlying fundamental cause has to do with the set of resources widely accessed by people with higher SES, although this explanation continues to be debated, as discussed in the next section. Nevertheless, the broad range of the social determinants of cancer underscores the need for transdisciplinary studies to parse out the roles that biology, individual behaviors, and social determinants play in shaping SES gradients in specific cancer sites.[6,51]

Multilevel Influence of Social Determinants on Cancer

Observed disparities in cancer mortality, survival, and incidence have motivated the study of social-level influences on the etiology of cancer. The development of social epidemiology within the field of epidemiology opened the way for multilevel analysis in cancer control. The overall framework proposed in Figure 1 is designed to encourage thinking about how different disciplines can contribute to solving the challenge of cancer–health disparities. Traditionally, population health and social factors have been the focus of epidemiologists, sociologists, economists, anthropologists,

political scientists, and systems theorists. Health care has been the purview of health services researchers, economists, behavioral and communications scientists, and clinicians. Individual human behaviors or risk factors that mediate health have been the realm of psychologists and behavioral scientists. The basic science disciplines of genetics, cell biology, immunology, and biochemistry have elucidated biological pathways and mechanisms. The task is finding ways to bring together two or more of these levels. Few biologists, for example, have yet addressed questions concerning how social factors "get under the skin" and result in cancer.

Social level. An active area of research is the influence of broad upstream factors on the political economy.[33,59,60] As noted already, making causal links with disease is most difficult at the level of fundamental causes. Ecosocial theory offers a useful conceptual model for linking fundamental causes and individual health, especially when combined with the core concept of "embodiment" that holds that bodies absorb, process, and reflect the conditions of human existence because people are both biological organisms and social beings.[61]

Many studies of broad social forces have raised concerns about the unhealthy side effects of production for profit. For example, the use of chemical fertilizers to improve yields of food may lead to environmental contamination with potentially carcinogenic agents.[62] Highly caloric processed foods are profitable but have little nutritional value.[63–66] In short, substantial health costs are associated with food production in the U.S.[67] The recognition of these unmeasured costs (as well as those incurred from natural-resource depletion) has led some economists to suggest that the sustainability and quality of life should be evaluated when the value of production is computed.[68] Much as ecosocial theory offers a new perspective for epidemiology, these economists have created a new approach to economics called *ecologic economics*, which addresses the interdependence and co-evolution between human economies and natural ecosystems. Many ecologic economists refer to this new field as a transdiscipline rather than a conventional discipline.[69,70]

Both the physical and built aspects of the environment influence cancer outcomes.[71] The physical environment influences both behavior and biology, and may help explain some observed trends and disparities in cancer incidence and outcomes. For example, minorities and lower-income groups face higher levels of exposure to environmental hazards, including industrial facilities, waste-treatment sites, or waste-disposal sites.[72] The effect of environmental risk factors on cancer in humans is hard to assess, especially because few data on carcinogens are available and specific long-term exposures on individuals and populations are not monitored.[73] The unequal distribution of environmental hazards has spawned an environmental justice movement[74] as well as discussion and debate on how to best measure and evaluate the impact of environmental hazards.[75]

The important policy issues that this social-level research has generated involve trade-offs between public health and economic profitability. Policy solutions require expertise from urban planning, engineering, law, economics, political science, and the biomedical disciplines as well as informed community input. Political decisions and economic incentives shape the built environment through zoning, construction investment, pollution limitations, available park and recreation areas, and the effectiveness of policing. The built environment, in turn, shapes community choices relevant to health, including cancer. For example, sidewalks or paths that lead to safe and desirable destinations for walking and cycling can increase physical activity.[76] Physical activity, in turn, is significantly associated with reduced colon-cancer mortality,[77,78] and is indirectly associated with lower mortality for many other cancers through reducing overweight and obesity.

Some groups, including those who are poor, black, Hispanic, or Native American, are more likely to experience overweight and obesity than the general public. They are also likely to reside where physical activity is more difficult, fruits and vegetables are less accessible, and tobacco and alcohol are prevalent.[79–81] In this way, residential segregation is another fundamental cause of racial disparities in health.[82]

Healthcare-delivery level. The impact of health care on cancer is related to insurance coverage, quality of care, and timely access to that care. Insurance, the financing mechanism used to pay for most health care in the U.S., may be the most important factor shaping health disparities.[83] Even after adjusting for sociodemographics, risk factors, morbidity, and self-rated health, the lack of health insurance is still linked to higher mortality.[84] Between 2000 and 2005, health insurance premiums grew by 73% (compared with cumulative inflation of approximately 14% and cumulative wage growth of 15%), and the percentage of employers offering health benefits fell from 69% to 60%.[85] From January through September 2006, 43.8 million people of all ages (16.9%) were uninsured,[86] and coverage rates varied substantially by race, ethnicity, and socioeconomic position. However, most cancer occurs in people aged ≥65 years, and only 7% of the individuals facing a new diagnosis of cancer were uninsured (approximately 86,000 in 1997).[41]

Although most people in the U.S. eventually obtain the necessary medical treatment, some do not receive it in a timely manner.[87,88] Without insurance coverage and a system to provide continuous care, patients must negotiate and pay for each step in their health care.

The President's Cancer Panel[42] has documented barriers to care that include elements inherent in the system (e.g., fragmentation of care); finances (e.g., lack of insurance or underinsurance); and physical environment (e.g., excessive distance from or physical barriers to accessing treatment facilities) as well as information and education barriers (both provider- and patient-related) and issues of cultural insensitivity and bias.[42]

Even with equal access, there is no guarantee of equal quality or use of services. Poor transportation, the lack of sick leave and time-off from work, and the need to supply child- and elder-care may pose insurmountable barriers to the optimal use of health care for people of low income and education.[89–92] Persistent racial, ethnic, and age differences in the receipt of primary therapy, conservative therapy, and adjuvant therapy provide indirect evidence of racial, ethnic, and age bias in access.[93–96] Improving the quality of care for cancer patients of all sociocultural backgrounds will require a major restructuring of the delivery of cancer care and the continuous monitoring of quality improvement and accountability.[41]

Behavioral/psychological level. Behaviors are often the mediating steps between social determinants and cancer outcomes. Behaviors long-recognized as important contributors to cancer include tobacco and alcohol use, poor diet, physical inactivity, high-risk reproductive behavior, and occupational hazards.[97] The mechanisms linking social-level factors, individual behaviors, and biology with cancer incidence and mortality are reasonably well-understood for tobacco, and the transdisciplinary research being conducted in tobacco control can serve as a model of how such research could be conducted for other cancer sites.[98] However, transdisciplinary research is still needed to elucidate the pathways and relationships of causation for those other sites.

Linkages between individual behaviors and fundamental causes have been posited, but the ability to demonstrate causation has been limited by cross-sectional data and linear statistical methods. Risk regulators, the range of intermediate factors that constrain or promote individual choice, have been posited as conceptual bridges linking fundamental causes and individual behaviors.[99] The concept of risk regulators locates individual choices within the broader social context of fundamental causes in order to provide testable hypotheses of association for multilevel transdisciplinary empirical research.

Individual behavior related to tobacco is intimately tied to the social context; social-level interventions to control tobacco are more effective than approaches addressing individual behavior.[100–102] Much of the success of tobacco-control efforts has come from changes in social policies such as federal excise taxes, workplace bans on smoking, media campaigns, clean-indoor-air policies, and the enforcement of restrictions on tobacco use by minors.[103,104]

Tobacco-control research is probably the best current model for effective transdisciplinary science, as it has grown from a focus on individual human behavior to include the understanding of the genetics of tobacco addiction, the distribution of smoking habits in the population, and how these complex relationships are affected by social policy.[105] Stokols and colleagues[106] evaluated the collaborative processes and the scientific and public-policy outcomes of the transdisciplinary approach used in one large tobacco control effort funded by the National Cancer Institute (NCI), and concluded that there was "progress toward intellectual integration" over the course of the initiative. However, methodologic challenges remain regarding how to evaluate large-scale science. A special supplement to *Nicotine and Tobacco Research* laid out in detail the vision for a transdisciplinary research strategy in tobacco control and how it was modeled, implemented, and evaluated.[107]

Other cancer outcomes await this depth of transdisciplinary scrutiny. Fruit and vegetable consumption may prevent cancer, but adherence to dietary guidelines for this consumption differs in the U.S. by race and SES.[64] A lack of exercise, poor diet, and obesity are associated with lower SES. A sedentary lifestyle is strongly related to lower income in every race and ethnic group and both genders.[108] Good evidence directly associates the lack of physical activity with cancers of the colorectum and prostate—and possibly breast cancer.[109] The Western diet staples of red meat and animal fat contribute to heart disease and cancer, especially colon cancer.[110] Overweight and obesity, also linked to certain cancers,[111] increased markedly in the U.S. for both children and adults between 1976 and 1980, and between 1988 and 1994,[112] and it seems clear that current diet and physical activity behaviors, as well as the practices of the food-marketing of industry in the U.S., promote obesity.[63,65,113] Differential uses of health services are key factors in outcomes related to these cancers, as discussed above.

Early-detection practices, a proven approach for secondary prevention for several cancer sites, are heavily dependent on the behaviors of individuals and providers. Screening and early detection, followed by timely treatment, increase survival for cervical, breast, colorectal, and possibly prostate cancers. Here again, the social context of healthcare access, quality, and price is critical, and the strongest predictors for the use of cancer screening are consistent health-insurance coverage and a consistent source of care.[114] Contractions in the economy and unemployment have been linked to a lessened likelihood that women, especially African-American women, will be diagnosed at an early stage of breast cancer, due to either less use of screening or less willingness to seek medical care for possible symptoms

of cancer.[115] Understanding both the web of causation and a means to equalize access to cancer screening poses challenges for transdisciplinary science.[37]

Biological level. Finally, transdisciplinary cancer research should assist the understanding of how the social context influences biological pathways in cancer. Only a small percentage (estimated at less than 5%) of cancers are currently attributable to inherited genetic susceptibility.[116] However, common genetic polymorphisms and epigenetic characteristics interact with or are influenced by the social environment, making it clear that a better understanding is needed of how the social context affects cancer biology.[117,118] At least two pathways have been proposed: (1) psychological stress linked to down-regulation in the immune system[119–121] and (2) distress interfering with DNA repair and apoptosis,[122,123] but there are likely many others yet to be described. For example, the population health concept of *weathering*, proposed to explain premature morbidity among African-American women,[124] is consistent with biological findings[125] and provides an example of *embodiment*.[12]

Theories that seek to explain how social forces affect the overall disease burden and yield inequalities in health outcomes tend to focus on either material conditions or psychosocial mechanisms.[126] Proponents of material conditions hold that social factors, ranging from advertising to income distribution, have an indirect effect on cancer through behaviors such as tobacco use, dietary choices, Internet use, access to cancer-screening resources, and the ability to choose where to live and work. These social factors are reflected in the nonrandom distribution of cancer incidence. Proponents of the psychosocial theory focus on how adverse social conditions work directly through physiologic pathways in the endocrine or immunologic systems to cause stress and disease.[127,128] These two types of theories are not mutually exclusive, and need to be pursued and linked to increase the nascent understanding of how social determinants of cancer "get under the skin." As mentioned above, Glass and McAtee[99] have begun this effort by conceptualizing risk regulators that mediate upstream factors and associate them with the biological pathways leading to cancer outcomes. Science is only beginning to explore the causal links between biological mechanisms and social determinants or fundamental causes, and more needs to be done. Perhaps most clearly of all, this challenge lends itself to a transdisciplinary approach.

Implications for Cancer Prevention and Control

A framework has been presented here for a transdisciplinary science approach to cancer control that will reveal the causal links between biology and the social determinants of cancer. Identified were the main endpoints available from cancer registries (i.e., incidence, survival, and mortality) and the value of examining social gradients in cancer outcomes. Multiple levels of analysis are needed to understand the diverse pathways and mechanisms behind these gradients and to determine how they are linked to the social environment; healthcare delivery; and behavioral, psychological, and biological levels in order to fashion more effective interventions. Interventions focused on changing individual behaviors in isolation have not proven adequate. Social policies to control tobacco use have been effective, and it may be time to consider other interventions at the social level, such as policies that will promote a sustainable economy, environmental justice, and the equalization of resource distribution, including healthcare access. Such an approach is consistent with national and international efforts aimed at modifying the social determinants of health.[129,130] The data available from current registry systems, surveys, and administrative records describe the range of biological, clinical, and social influences among different cancer sites. Especially when linked, they present rich opportunities for multilevel, transdisciplinary research all along the cancer continuum. Because of increased interest in population health, in transdisciplinary initiatives, and in eliminating health disparities, the time is ripe for transdisciplinary research and training.[8,131,132]

Substantial government and foundation support is now being directed toward these goals by the Robert Wood Johnson Foundation Health & Society Scholars Program,[133] the NIH Strategic Research Plan to Reduce and Ultimately Eliminate Health Disparities,[134] the 2009 Nation's Investment in Cancer Research Plan,[135] the Centers for Population Health and Health Disparities,[136] the Transdisciplinary Tobacco Use Research Centers,[137] NCI Centers of Excellence in Cancer Communication Research,[138] and the Transdisciplinary Research on Energetics and Cancer Centers.[139] It is hoped that readers will find this conceptual framework a useful beginning for taking advantage of these and other opportunities to further the development of transdisciplinary cancer control science.

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